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THERMOCOUPLE DETERIORATION PREDICTION DEVICE

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[There are no amendments to this patent.]

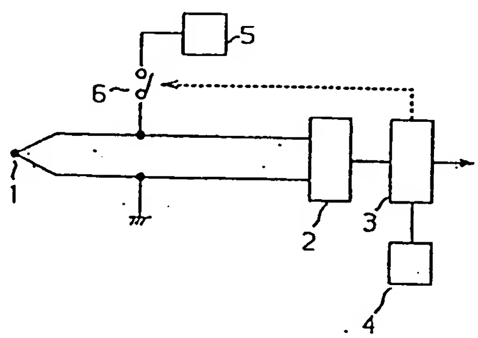
Abstract

Problem

To present a thermocouple deterioration prediction device having a simple configuration and capable of detecting and predicting the deterioration of a thermocouple easily.

Means to solve

Thermocouple deterioration prediction device equipped with a current source (5) for supplying a prescribed current to a thermocouple (1) intermittently and a processing means (3) for measuring the resistance value of the thermocouple (1) from drop in voltage when current is supplied to the thermocouple (1) from the current source (5) in order to predict and report a point in time at which deterioration will occur using a prescribed relationship based on change in said resistance value over time.



Claims

1. Thermocouple deterioration prediction device characterized by being equipped with a current source for supplying a prescribed current to a thermocouple intermittently and a processing means for measuring the resistance value of the thermocouple from drop in voltage when current is supplied to the aforementioned thermocouple from the aforementioned current source in order to predict and report a point in time at which deterioration will occur using a prescribed relationship based on the change in said resistance value over time.

2. Thermocouple deterioration prediction device described under Claim 1 and characterized in that the aforementioned prescribed relationship is revised according to results of measurement by the thermocouple.

Detailed explanation of the invention

[0001]

Technical field of the invention

The present invention pertains to a device for predicting deterioration of a thermocouple.

[0002]

Prior art

Thermocouples are widely utilized for the measurement of temperatures of heating furnaces and the like. However, used in high temperature atmosphere over a long period of time, they deteriorated.

[0003]

Because there has been no good method for predicting deterioration in the past, comparative testing was carried out periodically in reference to a standard thermocouple, or [the thermocouple] was replaced periodically after it had been used for a prescribed period of time based on experience.

[0004]

Problem to be solved by the invention

However, an expensive testing device must be prepared for comparative testing, which takes a significant amount of time. In addition, when the thermocouple is replaced periodically, a useable thermocouple is sometimes wasted by the replacement.

[0005]

In the light of the aforementioned points, the purpose of the present invention is to present a thermocouple deterioration prediction device having a simple configuration and capable of detecting and predicting deterioration of thermocouples easily.

[0006]

Means to solve the problem

The present invention is a thermocouple deterioration prediction device equipped with a current source for supplying a prescribed current to a thermocouple intermittently and a processing means for measuring the resistance value of the thermocouple from drop in voltage when current is supplied to the aforementioned thermocouple from the aforementioned current source in order to predict and report a point in time at which deterioration will occur using a prescribed relationship based on the change in said resistance value over time.

[0007]

Embodiment of the invention

Figure 1 is a diagram for explaining the configuration of an application example of this invention. In Figure 1, (1) is a thermocouple whose tip is provided as the target of measurement.

The thermal electromotive force from said thermocouple (1) is measured by means of a measurement means (2) containing an amplifier and an A/D converter, and said measured voltage is supplied to a processing means (3). The processing means (3) comprising a μCPU and the like carries out computation processing for converting the measured voltage into a temperature using a first relationship between the normal thermal electromotive force and temperature determined for the thermocouple type pre-stored in a memory (4) to allow a temperature output. In addition, the processing means (3) turns on a switching means (6) as needed or at prescribed intervals periodically in order to supply a prescribed current to the thermocouple (1) from a current source (5), the drop in voltage then is measured by the measurement means (2) and supplied to the processing means (3), and the processing means (3) measures the resistance value of the thermocouple (1). Then, the processing means (3) calculates a resistance value corresponding to the temperature previously measured by the thermocouple (1) from a second relationship between temperature and thermocouple resistance pre-stored in the memory (4) and compares said calculated resistance value with the resistance value of the thermocouple obtained from the voltage drop when the current was supplied to the thermocouple (1) from the current source (5) in order to detect and predict deterioration of the thermocouple (1).

[0008]

In other words, as shown by the solid line (A) in Figure 2, the aforementioned second relationship between the measuring temperature (T) and the resistance value (R) of the thermocouple, or a resistance ratio (R/R0) obtained by dividing by the resistance (R0) obtained at a certain temperature (T0), is then stored in the memory (4) in advance in addition to the first relationship between the normal thermal electromotive force and temperature. Then, a threshold level (for example, ±10%) for the range of resistance value is prescribed for each temperature as shown by the dotted-line curves (B) and (C); whereby, deterioration is detected when said [level] is exceeded. Then, a prescribed relationship is used to predict and report a point in time at which deterioration will occur, or the aforementioned threshold level will be reached, based on the change in the resistance value over time. Obviously, because resistance is proportional to voltage, a voltage value may be utilized for the comparison. Furthermore, because the resistance ratio (R/R0) is fixed according to the type of thermocouple (1), the length and the thickness of the thermocouple cause no effect when the resistance ratio (R/R0) is utilized for the comparison. In addition, temperature ratio (T/T0) relative to an appropriate reference temperature (T0) may be utilized for the comparison.

[0009]

Based on what has been described above, the thermal electromotive force of the thermocouple (1) is measured using the measurement means (2), and the temperature (T) is determined using the processing means (3) based on the aforementioned first relationship in order to calculate a reference resistance value (Rr) corresponding to the temperature (T) from the aforementioned second relationship between temperature and resistance of the thermocouple pre-stored in the memory (4). Next, the switching means (6) is turned on to supply a prescribed current (i) intermittently to the thermocouple (1) from the current source (5), and resistance value (R) of the thermocouple (1) is measured from voltage drop during the supply [of current]. Then, the processing means (3) compares said resistance value (R) with the reference resistance value (Rr) corresponding to the measuring temperature (T), and deterioration of the thermocouple (1) is predicted based on said difference. For example, as shown in Figure 2, when the resistance value (R) has penetrated the threshold levels (B) and (C), deterioration is detected, or the point in time at which said deterioration resistance value will be reached is predicted through calculation and forecast/prediction information is output.

[0010]

That is, for example, change in the resistance value (R) of the thermocouple (1) corresponding to the time (t) at which the threshold level at a certain prescribed temperature is reached and exceeded is shown in Figure 3. From the point (t1) in time at which the reference resistance value (Rr) has been exceeded slightly to reach the resistance value (R1) after deterioration has begun to progress, resistance value (R2) at the point (t2) in time after a prescribed amount of time (Δt) has passed from said [time (t1)] is obtained. Deterioration time (point in time) (tx) at which a deterioration resistance value (Rx) is reached is predicted through calculation using a prescribed relationship (deterioration function (F)), that is, a third relationship, stored in the memory (4) based on the changing rate $K = \Delta R/\Delta t$ of the change in the resistance value $\Delta R = R2 - R1$ relative to the change over the time $\Delta t = t2 - t1$; and said predicted time (tx), or the amount of time before said time (tx) is reached, is reported by processing means (3).

[0011]

For example, assuming simply that the deterioration function (F) is a linear function of resistance value (R) relative to time (t), deterioration time (tx) and the amount of time before it is reached (tx - t2) can be shown as follows based on the magnitude of the aforementioned changing rate (K).

[0012]

$$tx = (Rx - R2)/K + t2 \quad (1)$$
$$tx - t2 = (Rx - R2)/K \quad (2)$$

As shown above, the point (tx) in time at which deterioration occurs can be predicted and reported based on the change in the resistance value (R) over time using a prescribed deterioration function (F), and different deterioration functions (F) should be utilized depending on the type of the thermocouple (1) or the measuring temperature. In addition, a learning function can be provided to the processing means (3) for optimization; whereby, the thermocouple (1) is used for on-site measurement, and the deterioration function is corrected, renewed, and stored in the memory (4) according to the measurement result on the change in resistance relative to the time measured under a specific environment at the actual site.

[0013]

Incidentally, assuming that the resistance of the thermocouple (1) at the temperature (T) is denoted as R, the resistance at other parts, such as a part where a compensation conductor is present, as r1, and the thermal electromotive force at the temperature (T) as V0, when the current (i) is sent to the thermocouple (1) from the current source (5) during the normal measurement, the measured voltage (V1) can be expressed by the following equation.

[0014]

$$V1 = V0 + i\,(R + r1) = i \cdot R + (V0 + i \cdot r1) \quad (3)$$

From this [equation],

$$R = [V1 - (V0 + i \cdot r1)]/i \quad (4)$$

is obtained. Here, (V0 + i·r1) can be ignored if it is sufficiently small. Otherwise, V0 can be obtained through normal measurement, the current value (i) is a value to be set, and the resistance (r1) is already known from the type of the compensation conductor. Deterioration can be predicted in the manner using said resistance (R) obtained after correction according to the aforementioned third relationship between temperature and resistance.

[0015]

In addition, although the aforementioned deterioration prediction was explained based on the change in resistance relative to time, voltage, resistance ratio, and temperature are also included therein, presenting the same effect.

[0016]

Effect of the invention

As it has been described above, the present invention is a thermocouple deterioration prediction device equipped with a current source for supplying a prescribed current to a thermocouple intermittently and a processing means for measuring the resistance value of the thermocouple from drop in voltage when the current is supplied to the aforementioned thermocouple from the aforementioned current source in order to predict and report a point in time at which deterioration will occur using a prescribed relationship based on the change in said resistance value over time. Thus, a point in time at which deterioration of a thermocouple occurs can be detected and predicted constantly from the change in resistance of the thermocouple. What is more, because a comparison is made with a reference resistance value corresponding to the measuring temperature, deterioration can be predicted sufficiently regardless of the temperature under which the measurement is taken by the thermocouple. In addition, the length and the thickness of the thermocouple cause no effect because the relationship between resistance ratio and temperature can be utilized in addition to the resistance. In addition, if the temperature is increased during the actual operation, the temperature generated by the thermal electromotive force of the thermocouple and the resistance value at that time are obtained, and the relationship therein is used for deterioration prediction so various kinds of compensatory computation are no longer needed. In addition, if thermocouples are installed in multiple channels, deterioration of each thermocouple can be predicted by measuring the resistance value every time an input is taken in through each channel by means of an input switch. In addition, constant optimum deterioration prediction can be achieved through the provision of a learning function to the processing means; whereby, the thermocouple is used for on-site measurement, and the deterioration function is corrected, renewed, and stored in the memory according to measurement results on the change in resistance value relative to time measured under a specific environment at the actual site.

Brief description of the figures

Figure 1 is diagram for explaining the configuration of an application example of the present invention.

Figure 2 is diagram for explaining the operation of the application example of the present invention.

Figure 3 is diagram for explaining the operation of the application example of the present invention.

Explanation of symbols

1	Thermocouple
2	Measurement means
3	Processing means
4	Memory
5	Current source
6	Switching means

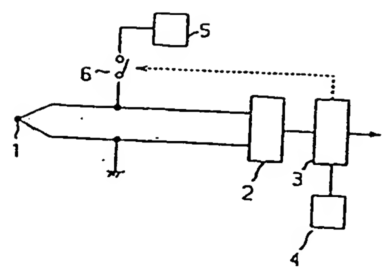


Figure 1

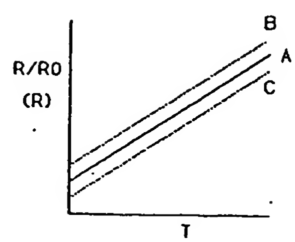


Figure 2

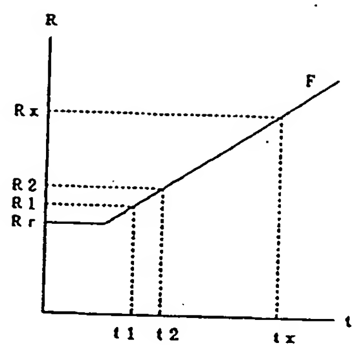


Figure 3

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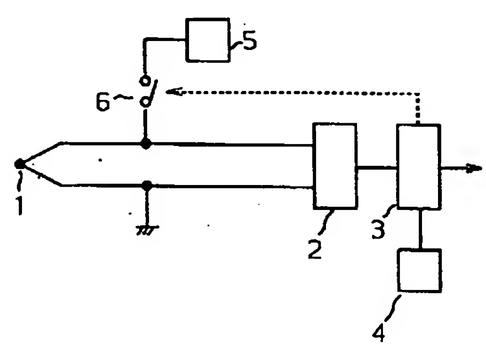
(54)【発明の名称】　熱電対劣化予測装置

(57)【要約】

【課題】簡易な構成で、容易に熱電対の劣化を検知、予測できる熱電対劣化予測装置を提供する。

【解決手段】熱電対1に所定の電流を断続的に供給する電流源5と、熱電対1に電流源5から電流を供給したときの電圧降下から熱電対1の抵抗値を測定し、この抵抗値の時間に対する変化に基き所定の関係を用い劣化時点を予測して報知する処理手段3とを備えるようにした熱電対劣化予測装置である。



【特許請求の範囲】

【請求項１】熱電対に所定の電流を断続的に供給する電流源と、前記熱電対に前記電流源から電流を供給したときの電圧降下から熱電対の抵抗値を測定し、この抵抗値の時間に対する変化に基き所定の関係を用い劣化時点を予測して報知する処理手段とを備えたことを特徴とする熱電対劣化予測装置。

【請求項２】前記所定の関係は、熱電対による測定結果から修正することを特徴とする請求項１記載の熱電対劣化予測装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】この発明は、熱電対の劣化を予測する装置に関するものである。

【０００２】

【従来の技術】熱電対は、加熱炉その他の温度測定に広く使用されている。ところが、高温雰囲気で長時間使用していると劣化するおそれがある。

【０００３】従来、劣化を予測する良い方法はなく、定期的に標準の熱電対と比較検定したり、経験的に所定時間使用する毎に定期的に交換していた。

【０００４】

【発明が解決しようとする課題】しかしながら、比較検定をする為には、高価な検定装置を用意する必要があり、検定の手間を大きく要し、また、熱電対を定期的に交換する場合では使用可能な熱電対まで交換することもあり無駄を生じるおそれがあった。

【０００５】この発明の目的は、以上の点に鑑み、簡易な構成で、容易に熱電対の劣化を検知、予測できる熱電対劣化予測装置を提供することである。

【０００６】

【課題を解決するための手段】この発明は、熱電対に所定の電流を断続的に供給する電流源と、前記熱電対に前記電流源から電流を供給したときの電圧降下から熱電対の抵抗値を測定し、この抵抗値の時間に対する変化に基き所定の関係を用い劣化時点を予測して報する処理手段とを備えるようにした熱電対劣化予測装置である。

【０００７】

【発明の実施の形態】図１は、この発明の一実施例を示す構成説明図である。図１において、１は先端部が測定対象に設けられた熱電対で、この熱電対１からの熱起電力は、増幅器、Ａ／Ｄ変換器等を含む測定手段２で測定され、この測定電圧は処理手段３に供給される。μＣＰＵ等よりなる処理手段３は、あらかじめメモリ４に記憶された熱電対の種類により定められた通常の熱起電力と温度との第１の関係を用い、測定電圧から温度に換算する演算処理を行い温度出力を取り出すことができる。また、処理手段３により必要時あるいは定期的に所定の間隔でスイッチ手段６をオンとし、電流源５の所定の電流を熱電対１に供給し、このときの電圧降下分を測定手段２で測定して処理手段３に供給し、処理手段３で熱電対１の抵抗値を測定する。そして、処理手段３は、あらかじめメモリ４に記憶された温度と熱電対の抵抗値との第２の関係から熱電対１で先に測定した温度に対応する抵抗値を算出し、この算出した抵抗値と熱電対１に電流源５から電流を供給したときの電圧降下から求めた熱電対の抵抗値と比較し、熱電対１の劣化を検知、予測する。

【０００８】つまり、図２の実線の曲線Ａで示すように、メモリ４には、通常の熱起電力と温度との第１の関係の他に、測定温度Ｔと、そのときの熱電対の抵抗値Ｒ、またはある温度Ｔ０のときの抵抗Ｒ０で割った抵抗比Ｒ／Ｒ０との上記第２の関係を記憶・格納しておく。そして、各温度に対し、点線の曲線Ｂ、Ｃで示す所定の抵抗値幅の限界レベル（例えば±１０％）を設け、これを越えたとき、劣化と判断することができる。そして、抵抗値の時間に対する変化に基き所定の関係を用い上記限界レベルとなる劣化時点をあらかじめ予測報知するようにする。勿論、抵抗と電圧は比例するので、電圧値で比較してもよい。なお、抵抗比Ｒ／Ｒ０は、熱電対の種類により一定であるので、抵抗比Ｒ／Ｒ０を用いて比較することにより、熱電対の長さ、太さ等の影響を受けることがない。また、適正な基準温度Ｔ０との温度比Ｔ／Ｔ０を用いて比較するようにしてもよい。

【０００９】以上のことから、熱電対１の熱起電力を測定手段２で測定し、上記第１の関係から処理手段３で温度Ｔを測定し、あらかじめメモリ４に記憶された温度と熱電対の抵抗値との上記第２の関係から温度Ｔに対応した基準の抵抗値Ｒｒを算出しておく。次にスイッチ手段６をオンとし、電流源５から熱電対１に所定の電流ｉを断続的に供給し、供給したときの電圧降下から熱電対１の抵抗値Ｒを測定する。そして、この抵抗値Ｒと測定温度Ｔに対応する基準の抵抗値Ｒｒとを処理手段３で比較し、この差から熱電対１の劣化を予測する。例えば、図２で示すように、抵抗値Ｒが限界レベルＢ、Ｃを越えたとき、劣化となるが、この劣化抵抗値に到達する時点を予測計算し、予知・予測情報を外部に報知出力する。

【００１０】つまり、図３に、例えばある所定の温度における限界レベルに達して越えて行くような時間ｔに対する熱電対１の抵抗値Ｒの変化を示す。劣化が進行し始め、基準の抵抗値Ｒｒをやや越えた抵抗値Ｒ１となった時刻ｔ１において、これより所定の時間Δｔ経過した時刻ｔ２の抵抗値Ｒ２を求める。これらの時間的変化Δｔ＝ｔ２－ｔ１に対する抵抗値変化ΔＲ＝Ｒ２－Ｒ１の変化率Ｋ＝ΔＲ／Δｔから、メモリ４に格納された第３の関係である所定の関係（劣化関数Ｆ）を用い、劣化抵抗値Ｒｘとなる劣化時刻（時点）ｔｘを予測計算し、この予測時刻ｔｘ又はこの時刻ｔｘになるまでの時間を処理手段３は外部に報知する。

【００１１】例えば、概略、劣化関数Ｆが時間ｔに対する抵抗値Ｒの一次関数とすれば、上記変化率Ｋの大きさ

から、劣化時刻ｔｘ及びそれまでの時間ｔｘ－ｔ２は、次式となる。

【００１２】

$$tx = (Rx - R2) / K + t2 \quad (1)$$

$$tx - t2 = (Rx - R2) / K \quad (2)$$

このように、抵抗値Ｒの時間ｔに対する変化に基き所定の劣化関数Ｆを用い劣化時点ｔｘを予測して報知することができるが、この劣化関数Ｆは、熱電対１の種類又は測定温度毎に異なるものを用いるとよい。また、熱電対１による現場での測定を行って、実際の現場で特定の環境で測定した時間に対する抵抗値変化の測定結果から、劣化関数を修正して更新しメモリ４に格納するようにする学習機能を処理手段３に設け、常に最適のものとできる。

【００１３】ところで、通常の測定時、電流源５より熱電対１に電流ｉを流したとき、温度Ｔとされる熱電対１の抵抗値をＲ、それ以外の部分の補償導線等の部分の抵抗値をｒ１、温度Ｔのときの熱起電力をＶ０とすると測定電圧Ｖ１は次式となる。

【００１４】

$$V1 = V0 + i\,(R + r1) = i \cdot R + (V0 + i \cdot r1) \quad (3)$$

これより

$$R = [V1 - (V0 + i \cdot r1)] / i \quad (4)$$

が求まる。ここで、（Ｖ０＋ｉ・ｒ１）は、十分小さければ無視でき、あるいはＶ０は通常の測定により求まり、電流値ｉは設定値であり、抵抗値ｒ１は、補償導線等の種類により既知である。この補正して求められた抵抗値Ｒを用いて上記温度と熱電対の抵抗値との第３の関係等を用いて同様に劣化予測を行うことができる。

【００１５】また、上記劣化予測は、抵抗値の時間に対する変化に基くものについて説明したが、電圧値、抵抗値比、温度比等も、これに含まれ、同様の効果が得られる。

【００１６】

【発明の効果】以上述べたように、この発明は、熱電対に所定の電流を断続的に供給する電流源と、前記熱電対に前記電流源から電流を供給したときの電圧降下から熱電対の抵抗値を測定し、この抵抗値の時間に対する変化に基き所定の関係を用い劣化時点を予測して報知する処理手段とを備えるようにした熱電対劣化予測装置である。このため、常時、熱電対の抵抗値変化から、熱電対の劣化の時点を検知、予測することができ、しかも、そのときの測定温度に対応した基準の抵抗値と比較しているので、熱電対がどのような温度で測定していたとしても、十分に劣化の予測が可能となる。また、抵抗の他に抵抗比と温度との関係を用いることで、熱電対の長さ、太さ等の影響を受けることがない。また、実際の稼働時に温度上昇させて、熱電対の熱起電力による温度と、そのときの抵抗値を求め、これの関係を用いて、劣化予測をすれば、種々の補正演算は不要となる。また、熱電対が複数チャンネルの場合、入力切換器で各チャンネルの入力取り込み毎に抵抗値測定を行って、各熱電対毎の劣化予測が可能となる。また、熱電対による現場での測定を行って、実際の現場で特定の環境で測定した時間に対する抵抗値変化の測定結果から学習し、劣化関数を修正して更新しメモリに格納するようにする学習機能を処理手段に設け、常に最適劣化予測ができる。

【図面の簡単な説明】

【図１】この発明の一実施例を示す構成説明図である。

【図２】この発明の一実施例を示す動作説明図である。

【図３】この発明の一実施例を示す動作説明図である。

【符号の説明】

１　熱電対

２　測定手段

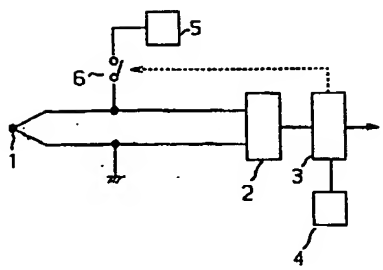
３　処理手段

４　メモリ

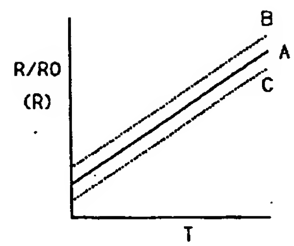
５　電流源

６　スイッチ手段

【図1】



【図2】



【図3】